Radio Testing of an **INTELLIGENT VEHICLE GATEWAY**

Model(s): IVG LTE

In accordance with 47 CFR FCC Part 15C

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Prepared for:
Omnitracs, LLC
9276 Scranton Road, Suite 200,
San Diego, California, USA 92121

COMMERCIAL-IN-CONFIDENCE

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RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Approved By	Foo Kai Maun	11 Jul 2018	
Prepared By	Quek Keng Huat	10 Jul 2018	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD PSB document control rules.

EXECUTIVE SUMMARY
A sample of this product was tested and found to be in compliance with the mentioned standard(s).

TÜV SÜD PSB

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LA-2007-0380-A
LA-2007-0381-F
LA-2007-0382-B
LA-2007-0383-G
LA-2007-0384-G
LA-2007-0385-E
LA-2007-0386-C
LA-2010-0464-D

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council. Inspections/Calibrations/Tests marked "Not SAC-SINGLAS Accredited" in this Report are not included in the SAC-SINGLAS Accreditation Schedule for our inspection body/laboratory.

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Contents

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1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	11 Jul 2018

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1.2 Introduction

Applicant	:	Omnitracs, LLC 9276 Scranton Road, Suite 200, San Diego, California, USA 92121
Manufacturer	:	PCI Limited 35 Pioneer Road North Singapore 628475
Factory	:	PT PCI ELEKTRONIK INTERNASIONAL Panbil Industrial State Factory C Lot 2-3 Jalan Ahmad Yani Muka Kuning Indonesia 29433
FCC ID	:	2AE8ZIVG2
Model Number(s)	:	IVG LTE
Serial Number(s)	:	108500100 (Radiated Unit) 108500323 (Conducted Unit)
Number of Samples Tested	:	1
Test Sample(s) Condition	:	Good
Quotation Reference	:	2191083345
Test Specification/Issue/Date	:	FCC 47 CFR Part 15C
Test Sample(s) Received Date	:	24 May 2018
Start of Test	:	30 May 2018
Finish of Test	:	11 Jul 2018

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1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with specifications as shown below.

Specification Clause	Test Description	Result	Comments/Base Standard
47 CFR FCC Part 15			
15.107(a), 15.207	Conducted Emissions	Not Applicable *See Note 4	ANSI C63.4: 2014 ANSI C63.10: 2013
15.109(a), 15.205, 15.209	Radiated Emissions (Spurious Emissions Inclusive Restricted Bands Requirement)	Pass	ANSI C63.4: 2014 ANSI C63.10: 2013
15.247(a)(1)	Carrier Frequency Separation	Not Tested *See Note 7	ANSI C63.10: 2013
	Spectrum Bandwidth (20dB Bandwidth Measurement)		
15.247(a)(1)(iii)	Number of Hopping Frequencies	Not Tested *See Note 7	ANSI C63.10: 2013
	Average Frequency Dwell Time		
15.247(b)(1)	Maximum Peak Power	Pass	ANSI C63.10: 2013
15.247(d)	RF Conducted Spurious Emissions	Not Tested *See Note 7	ANSI C63.10: 2013
15.247(d)	Band Edge Compliance (Conducted)	Not Tested *See Note 7	ANSI C63.10: 2013
15.247(d)	Band Edge Compliance (Radiated)	Pass	ANSI C63.10: 2013
15.247(e)	Peak Power Spectral Density	Not Tested *See Note 7	ANSI C63.10: 2013
15.35(c)	Duty Cycle Factor Computation	Not Applicable *See Note 5	ANSI C63.10: 2013
2.1091	Maximum Permissible Exposure	Not Tested *See Note 8	

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Notes

1. All the measurements in section 15.247 were done based on conducted measurements except Band Edge Compliance (Radiated) test.

2. The EUT is a Class B device when in non-transmitting state and meets the 47 CFR FCC Part15B Class B requirements.

3. The maximum measured RF power of the Equipment Under Test is 1.46dBm.

4. The Equipment Under Test (EUT) is a DC operated device and contains no provision for public utility connections.

5. The EUT was operated in continuous transmission, ie 100% duty cycle.

6. The EUT was tested using fully charged batteries with DC voltage of 12.0V.

7. The RF module of the Equipment Under Test (EUT) is a FCC & IC certified module (FCC ID: N6C-SDMAC, IC: 4908A-SDMAC). PCI Limited declares that the module was integrated into the main board without modifications in hardware nor firmware and the RF module used was tested and reported in UL Japan, Inc. issued test report, 11182619H-B-R2 dated 8th Nov 2016.

8. Please refer to the SAR report for more details.

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1.4 Product Information

1.4.1 Technical Description

Description	:	The Equipment Under Test(s) (EUT(s)) is an **INTELLIGENT VEHICLE GATEWAY**
Microprocessor	:	NXP MCIMX6Q7CVT08AD
Operating Frequency	:	800MHz
Clock / Oscillator Frequency	:	24MHz
Modulation	:	Wi-Fi: IEEE802.11a/b/g/n/ac Bluetooth 4.1 BR/EDR/LE
Antenna Gain	:	Wi-Fi & Bluetooth 2.4GHz – 4.74dBi 5GHz – 3.78dBi
Port / Connectors	:	1 x 20-pin port for 12VDC Input 2 x USB Type A ports 1 x micro SD port
Rated Power	:	Input 12Vdc 1A
Accessories	:	Plastic Holster

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1.4.2 Test Configuration and Modes of Operation

<table>
<tr><th>Mode(s)</th><th>Description</th></tr>
<tr><td>a. Maximum RF power transmission with frequency hopping off

b. Maximum RF power transmission with frequency hopping on</td><td>The EUT was exercised by operating in the mode “a”, i.e transmitting at lower, middle and upper channels as shown below one at a time. For Band Edge Compliance, only lower and upper channels were evaluated.
<table>
<tr><th>Transmit Channel</th><th>Frequency (GHz)</th></tr>
<tr><td>Channel 0 (Lower Channel)</td><td>2.402</td></tr>
<tr><td>Channel 39 (Middle Channel)</td><td>2.441</td></tr>
<tr><td>Channel 78 (upper Channel)</td><td>2.480</td></tr>
</table>
The EUT was exercised by operating in maximum continuous transmission with frequency hopping on (mode ‘b”).</td></tr>
</table>

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1.5 Test Facilities Registrations

Requirements	Registration Numbers
FCC	994109 (Test Firm Registration Number) SG0002 (Designation Number)
ISED	Science Park 2932I-1 (3m and 10m Semi-Anechoic Chamber) International Business Park 2932N-1 (10m Semi-Anechoic Chamber)
VCCI	Science Park R-1335 (10m ANC), G-29 (10m ANC) C-2306 (C.E @ Lab 3) T-1471 (Telecom Ports @ Lab 3) International Business Park R-3324 (10m ANC), G-203 (10mANC) C-4933 (C.E @ CEIBP) T-2403 (Telecom Ports @ CEIBP)
BSMI	SL2-IS-E-6001R *[CNS-13803 (ISM Equipment)]* SL2-IN-E-6001R *[CNS-13438 (IT Equipment)]* SL2-R1/R2-E-6001R *[CNS-13439 (Broadcast Receivers)]* SL2-A1-E-6001R *[CNS-13783-1 (Household Appliances)]* SL2-L1-E-6001R *[CNS-14115 (Lighting Equipment)]*

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1.6 Supporting Equipment

Equipment Description (Including Brand Name)	Model, Serial & FCC ID Number	Cable Description (List Length, Type & Purpose)
Lenovo ThinkPad R400	M/N: 7440 – C97 S/N: L3-ALB2G 09/03 FCC ID: DoC	
Lenovo AC Adapter	M/N: PA-1650-161 S/N: 11S92P1158Z1ZD2H9371JD FCC ID: DoC	1.80m unshielded power cable
TP-Link AC1750 Wireless Dual Band Gigabit Router	M/N: Archer C7 S/N: 2166545001077 FCC ID: DoC	1.50m unshielded RJ45 cable
TP-Link AC Adapter	M/N: T120200-2D1 S/N: 167351 FCC ID: DoC	1.80m unshielded power cable
Logitech Media Keyboard	M/N: K200 S/N: Nil FCC ID: DoC	1.50m unshielded signal cable
Dell Optical Mouse	M/N: MO56U0A S/N: G0N0419Z FCC ID: DoC	1.50m unshielded signal cable

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2 Test Details

2.1 Radiated Emissions (Spurious Emissions Inclusive Restricted Bands Requirement)

2.1.1 Test Limits

Frequency Range (MHz)	Quasi-Peak Limit Values (dBµV/m)
0.009 - 0.490 *	20 log [2400 / F (kHz)] @ 300m
0.490 - 1.705	20 log [24000 / F (kHz)] @ 30m
1.705 - 30.0	30.0 @ 30m
30 – 88	40.0 @ 3m
88 – 216	43.5 @ 3m
216 – 960	46.0 @ 3m
Above 960 *	54.0 @ 3m
* For frequency bands 9kHz – 90kHz, 110kHz – 490kHz and above 1GHz, average detector was used. A peak limit of 20dB above the average limit does apply.	

Restricted Bands

MHz			MHz			MHz			GHz		
0.090	-	0.110	16.42	-	16.423	399.9	-	410	4.5	-	5.15
0.495	-	0.505	16.69475	-	16.69525	608	-	614	5.35	-	5.46
2.1735	-	2.1905	16.80425	-	16.80475	960	-	1240	7.25	-	7.75
4.125	-	4.128	25.5	-	25.67	1300	-	1427	8.025	-	8.5
4.17725	-	4.17775	37.5	-	38.25	1435	-	1626.5	9.0	-	9.2
4.20725	-	4.20775	73	-	74.6	1645.5	-	1646.5	9.3	-	9.5
6.215	-	6.218	74.8	-	75.2	1660	-	1710	10.6	-	12.7
6.26775	-	6.26825	108	-	121.94	1718.8	-	1722.2	13.25	-	13.4
6.31175	-	6.31225	123	-	138	2200	-	2300	14.47	-	14.5
8.291	-	8.294	149.9	-	150.05	2310	-	2390	15.35	-	16.2
8.362	-	8.366	156.52475	-	156.52525	2483.5	-	2500	17.7	-	21.4
8.37625	-	8.38675	156.7	-	156.9	2690	-	2900	22.01	-	23.12
8.41425	-	8.41475	162.0125	-	167.17	3260	-	3267	23.6	-	24.0
12.29	-	12.293	167.72	-	173.2	3332	-	3339	31.2	-	31.8
12.51975	-	12.52025	240	-	285	3345.8	-	3358	36.43	-	36.5
12.57675	-	12.57725	322	-	335.4	3600	-	4400	Above 38.6		
13.36	-	13.41									

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2.1.2 Test Setup

2.1.2.1 The EUT and supporting equipment were set up in accordance with the requirements of the standard as shown in the setup photos.

2.1.2.2 The filtered power supply for the EUT and supporting equipment were tapped from the appropriate power sockets located on the turntable.

2.1.2.3 The relevant broadband antenna was set at the required test distance away from the EUT and supporting equipment boundary.

2.1.3 Test Method

2.1.3.1 The EUT was switched on and allowed to warm up to its normal operating condition.

2.1.3.2 A prescan was carried out to pick the worst emission frequencies from the EUT. For EUT which is a portable device, the prescan was carried out by rotating the EUT through three orthogonal axes to determine which altitude and equipment arrangement produces such emissions.

2.1.3.3 The test was carried out at the selected frequency points obtained from the pre-scan. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna polarization, and adjusting the antenna height in the following manner:

a. Vertical or horizontal polarisation (whichever gave the higher emission level over a full rotation of the EUT) was chosen.
b. The EUT was then rotated to the direction that gave the maximum emission.
c. Finally, the antenna height was adjusted to the height that gave the maximum emission

2.1.3.4 A Quasi-peak measurement was made for that frequency point if it was less than or equal to 1GHz.For frequency point in range of 9kHz – 90kHz, 110kHz – 49k0kHz and above 1GHz, both Peak and Average measurements were carried out.

2.1.3.5 The measurements were repeated for the next frequency point, until all selected frequency points were measured.

2.1.3.6 The frequency range covered was from the lowest radio frequency signal generated from the EUT, without going below 9kHz to 10th harmonics of the EUT fundamental frequency, using the loop antenna for frequency below 30MHz, Bi-log antenna for frequencies from 30MHz up to 1GHz, and the Horn antenna above 1GHz.

Sample Calculation Example

At 300 MHz	Q-P limit = 46.0 dBμV/m
Log-periodic antenna factor & cable loss at 300 MHz = 18.5 dB Q-P reading obtained directly from EMI Receiver = 40.0 dBμV/m (Calibrated level including antenna factors & cable losses)	
Therefore, Q-P margin = 46.0 - 40.0 = 6.0	i.e. 6.0 dB below Q-P limit

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2.2.5 Test Results

Test Input Power	12Vdc	Temperature	24ºC
Test Distance	10m (<30MHz) 3m (≥30MHz – 25GHz)	Relative Humidity	60%
Mode	Frequency Hopping Off – GFSK (Worst Mode)	Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit

Spurious Emissions ranging from 9kHz – 30MHz (for 9kHz – 90kHz, 110kHz – 490kHz) *See Note 4 & 5

Freq (GHz)	Peak Value (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	AV Value (dBµV/m)	AV Limit (dBµV/m)	AV Margin (dB)	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Ch
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Spurious Emissions ranging from 9kHz – 30MHz *See Note 4& 5

Frequency (MHz)	Q-P Value (dBµV/m)	Q-P Limit (dBµV/m)	Q-P Margin (dB)	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Channel
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Spurious Emissions ranging from 30MHz – 1GHz

Frequency (MHz)	Q-P Value (dBµV/m)	Q-P Limit (dBµV/m)	Q-P Margin (dB)	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Channel (Worst)
222.4060	31.1	46.0	15.3	300	106	H	78
249.8930	31.0	46.0	15.4	100	265	V	78
273.4530	28.8	46.0	17.6	300	222	H	78
375.5450	23.4	46.0	23.0	100	265	V	78
479.6020	26.7	46.0	19.7	100	178	V	78
624.8880	30.6	46.0	15.8	100	284	V	78

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Spurious Emissions above 1GHz – 25GHz

Freq (GHz)	Peak Value (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	AV Value (dBµV/m)	AV Limit (dBµV/m)	AV Margin (dB)	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Ch
1.4959	45.3	74.0	28.7	37.5	54.0	16.5	300	245	V	0
1.8838	68.2	74.0	5.8	51.8	54.0	2.2	197	81	H	0
1.9513	62.5	74.0	11.5	48.2	54.0	5.8	200	80	V	0
2.1335	44.3	74.0	29.7	30.9	54.0	23.1	400	275	V	0
3.7628	51.0	74.0	23.0	42.9	54.0	11.1	200	240	V	0
5.0076	44.2	74.0	29.8	36.7	54.0	17.3	200	236	V	0

Spurious Emissions above 1GHz – 25GHz

Freq (GHz)	Peak Value (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	AV Value (dBµV/m)	AV Limit (dBµV/m)	AV Margin (dB)	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Ch
1.4149	46.7	74.0	27.3	39.7	54.0	14.3	200	225	V	39
1.5870	48.2	74.0	25.8	33.3	54.0	20.7	200	335	V	39
1.8840	69.4	74.0	4.6	52.7	54.0	1.3	196	84	H	39
1.9513	62.3	74.0	11.7	53.1	54.0	0.9	200	350	V	39
3.7628	50.0	74.0	24.0	42.1	54.0	11.9	200	235	H	39
5.0076	44.1	74.0	29.9	37.5	54.0	16.5	200	90	V	39

Spurious Emissions above 1GHz – 25GHz

Freq (GHz)	Peak Value (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	AV Value (dBµV/m)	AV Limit (dBµV/m)	AV Margin (dB)	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Ch
1.3846	41.7	74.0	32.3	34.7	54.0	19.3	200	250	V	78
1.4959	42.9	74.0	31.1	39.8	54.0	14.2	200	15	V	78
1.8842	71.2	74.0	2.8	53.0	54.0	1.0	188	80	H	78
1.9513	64.8	74.0	9.2	52.9	54.0	1.1	200	211	V	78
3.7628	50.8	74.0	23.2	42.2	54.0	11.8	200	242	H	78
5.0076	45.1	74.0	28.9	37.1	54.0	16.9	200	91	V	78

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Notes

1.	All possible modes of operation were investigated. Only the worst case emissions measured, using the correct CISPR detectors, are reported. All other emissions were relatively insignificant.
2.	A "positive" margin indicates a PASS as it refers to the margin present below the limit line at the particular frequency. Conversely, a “negative” margin indicates a FAIL.
3.	EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings: 9kHz – 30MHz RBW: 9kHz VBW: 30kHz 30MHz - 1GHz RBW: 120kHz VBW: 1MHz >1GHz RBW: 1MHz VBW: 3MHz
4.	“--” indicates no emissions were found and shows compliance to the limits.
5.	The measurement was done at 10m. The measured results were extrapolated to the specified test limits as specified in § 15.209 (a) based on 40dB/decade.
6.	Quasi-peak measurement was used for frequency measurement up to 1GHz. Average and peak measurements were used for emissions above 1GHz. The average measurement was done by averaging over a complete cycle of the pulse train, including the blanking interval as the pulse train duration does not exceed 0.1 second.
7.	A "positive" margin indicates a PASS as it refers to the margin present below the limit line at the particular frequency. Conversely, a “negative” margin indicates a FAIL.
8.	EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings: 30MHz - 1GHz RBW: 120kHz VBW: 1MHz >1GHz RBW: 1MHz VBW: 3MHz
9.	The upper frequency of radiated emission investigations was according to requirements stated in Section 15.33 (a) for intentional radiators & Section 15.33 (b) for unintentional radiators.
10.	The channel in the table refers to the transmit channel of the EUT.

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2.2 Maximum Peak Power

2.2.1 Test Limits

The EUT shows compliance to the requirements of this section, which states the EUT employing at least 75 non-overlapping hopping channels shall not exceed 1W (30dBm). For the EUT employs other frequency hopping systems, the peak power shall not greater than 0.125W (21dBm).

2.2.2 Test Setup

2.2.2.1 The EUT and supporting equipment were set up as shown in the setup photo.

2.2.2.2 The power supply for the EUT was connected to a filtered mains.

2.2.2.3 The RF antenna connector was connected to a power meter via a low-loss coaxial cable.

2.2.2.4 All other supporting equipment were powered separately from another filtered mains.

2.2.3 Test Method

2.2.3.1 The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode, non-hopping with transmitting frequency at lower channel.

2.2.3.2 The maximum peak power of the transmitting frequency was detected and recorded.

2.2.3.3 The measurement were repeated with the transmitting frequency was set to middle channel and upper channel respectively.

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2.2.4 Test Results

Test Input Power	12Vdc	Temperature	24ºC
Antenna Gain	4.74 dBi	Relative Humidity	60%
Mode	Frequency Hopping Off	Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit

GFSK

Channel	Channel Frequency (GHz)	Maximum Peak Power (W)	Limit (W)
Lower	2.402	0.0011	1.0
Middle	2.441	0.0012	1.0
Upper	2.480	0.0014	1.0

(π/4) DQPSK

Channel	Channel Frequency (GHz)	Maximum Peak Power (W)	Limit (W)
Lower	2.402	0.0008	1.0
Middle	2.441	0.0009	1.0
Upper	2.480	0.0010	1.0

8DPSK

Channel	Channel Frequency (GHz)	Maximum Peak Power (W)	Limit (W)
Lower	2.402	0.0007	1.0
Middle	2.441	0.0007	1.0
Upper	2.480	0.0008	1.0

Notes

1.	Nil.

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2.3 Band Edge Compliance (Radiated)

2.3.1 Test Limits

The EUT shows compliance to the requirements of this section, which states in any 100kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator (EUT) is operating, the radio frequency power that is produced by the EUT shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands shall comply to the radiated emission limits specified in 15.209.

2.3.2 Test Setup

2.3.2.1 The EUT and supporting equipment were set up as shown in the setup photo.

2.3.2.2 The power supply for the EUT was connected to a filtered mains.

2.3.2.3 The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 100kHz and 300kHz to show compliance of spurious at band edges are at least 20dB below the carriers. For restricted band spurious at band edges, peak and average measurement plots were taken using the following setting:

a. Peak Plot:
RBW = 1MHz, VBW = 3RBW

b. Average Plot
RBW = 1MHz, VBW = 10Hz

2.3.2.4 All other supporting equipment were powered separately from another filtered mains.

2.3.3 Test Method

2.3.3.1 The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode with frequency hopping sequence on.

2.3.3.2 The frequency span of the spectrum analyser was set to wide enough to capture the lower band edge of the transmission band, 2.400GHz and any spurious emissions at the band edge.

2.3.3.3 The spectrum analyser was set to max hold to capture any spurious emissions within the span. The signal capturing was continuous until no further spurious emissions were detected.

2.3.3.4 The measurements were repeated with the frequency span of the spectrum analyser was set to wide enough to capture the upper band edge frequency of the transmission band, 2.4835GHz and the any spurious emissions at the band-edge.

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2.3.4 Test Results

Test Input Power	12Vdc	Temperature	24ºC
Attached Plots	1 – 6	Relative Humidity	60%
Mode	Frequency Hopping Off	Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit

No significant signal was found and they were below the specified limit.

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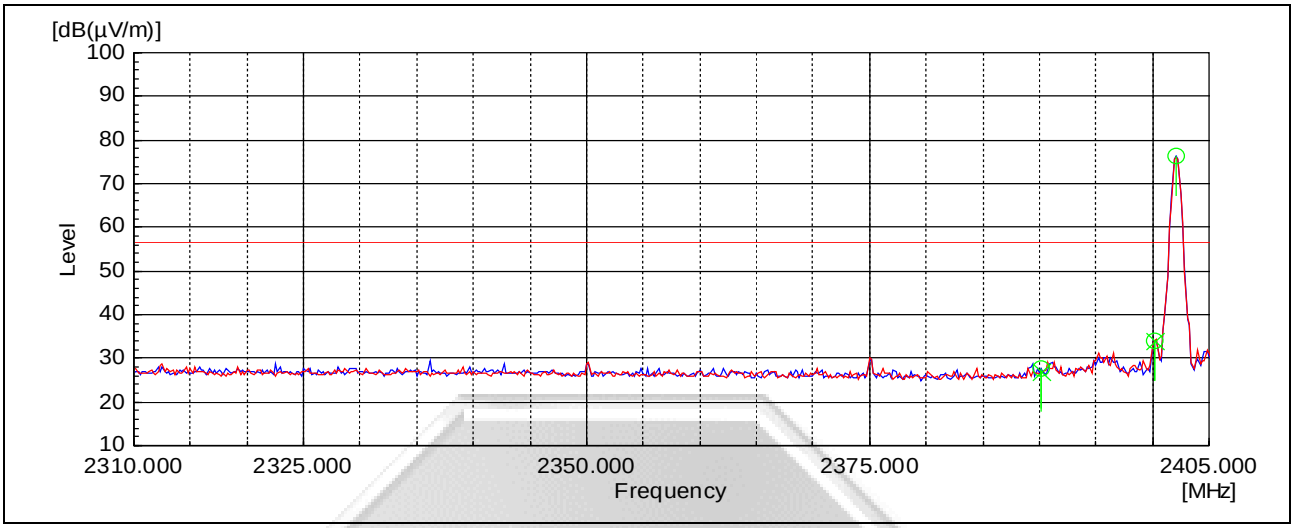
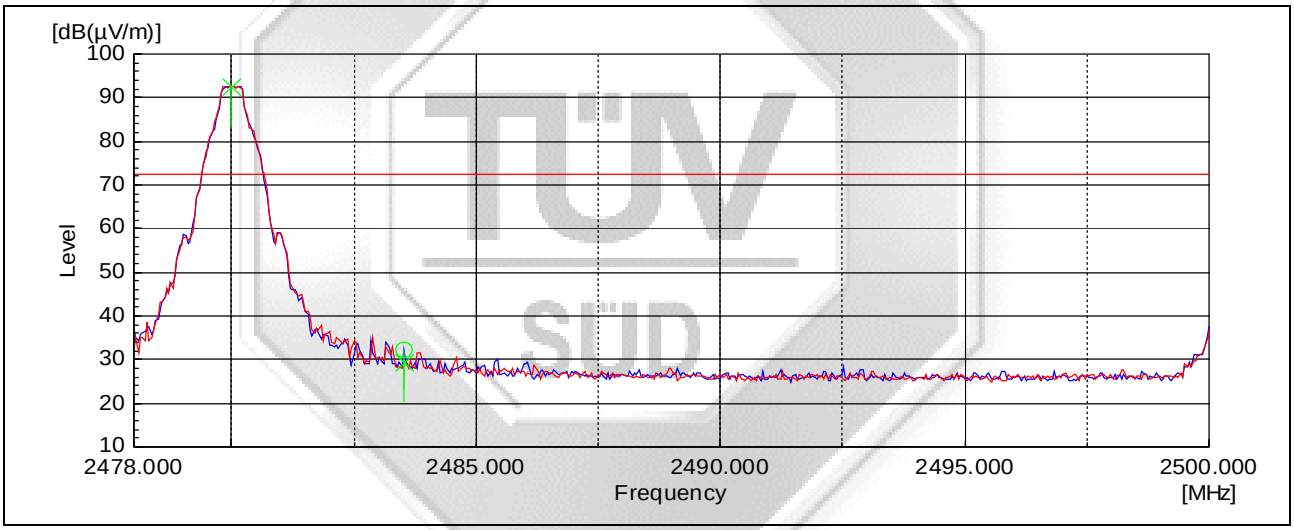
Band Edge Compliance (Radiated) Plots (20dB Delta from Carrier at Band Edge)



Plot 1 – Lower Band Edge at 2.4000GHz



Plot 2 – Upper Band Edge at 2.4835GHz

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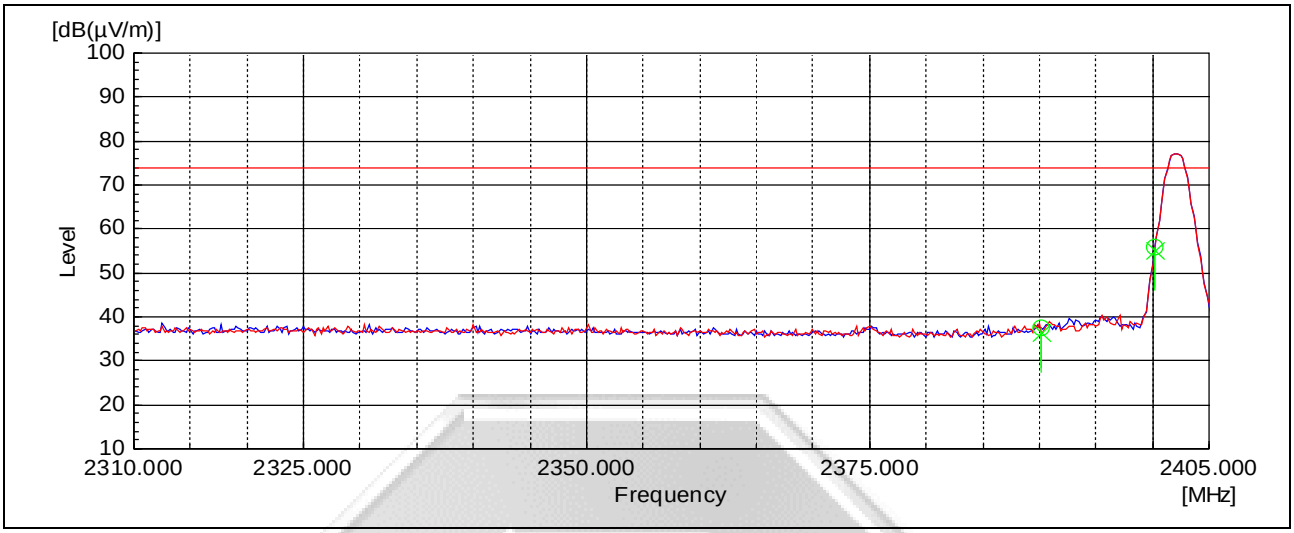
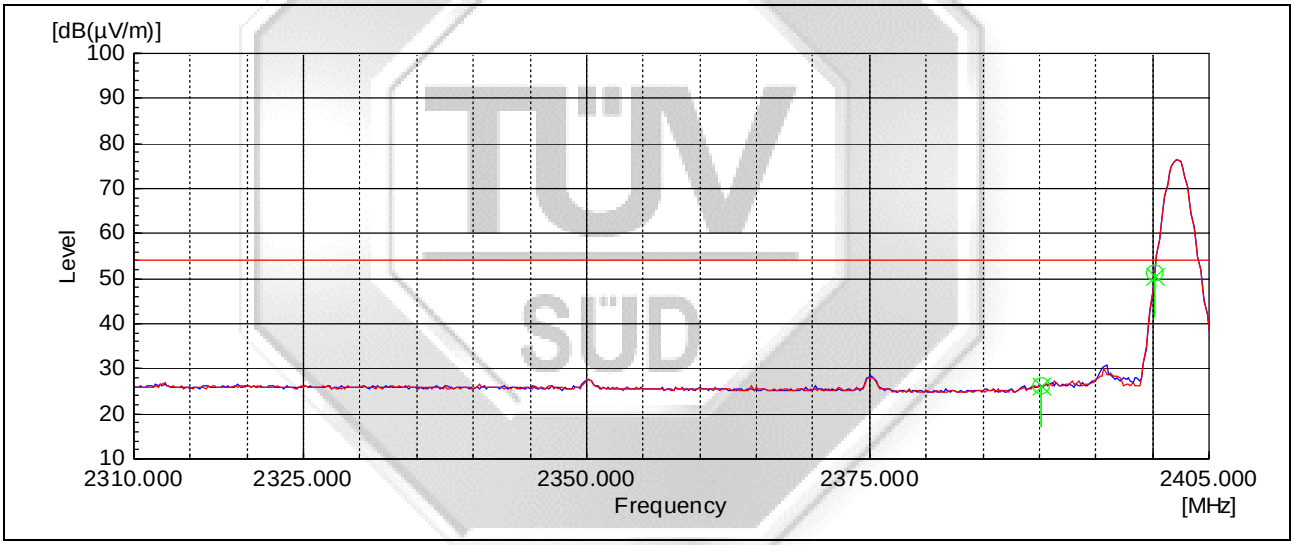
Band Edge Compliance (Radiated) Plots (Restricted Band)



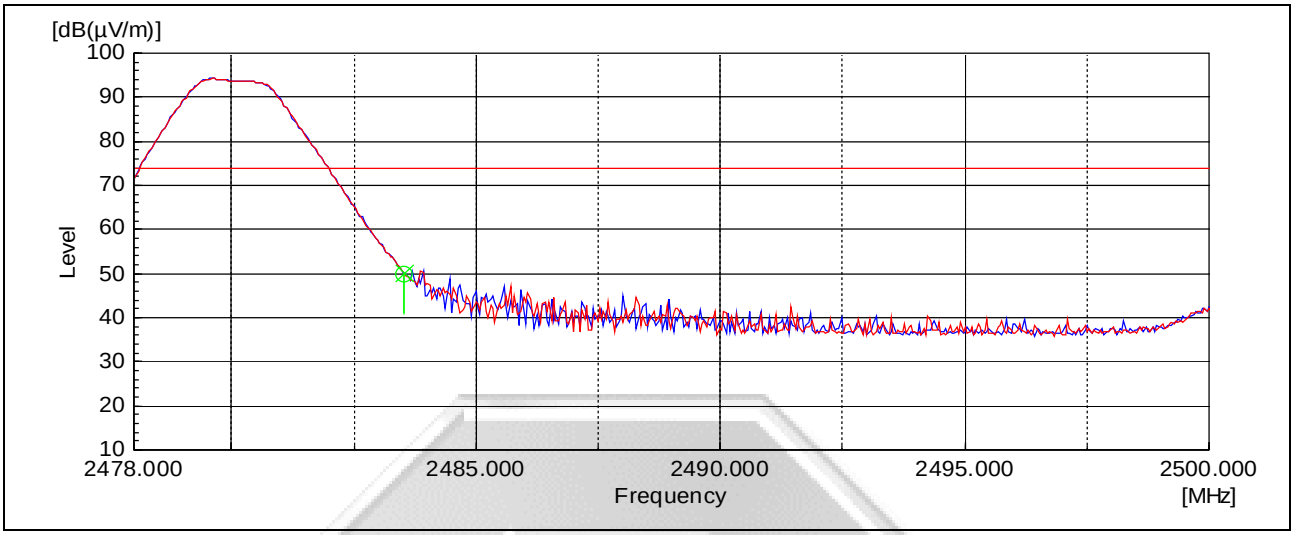
Plot 3 – Peak Plot at Lower Band Edge at 2.4000GHz



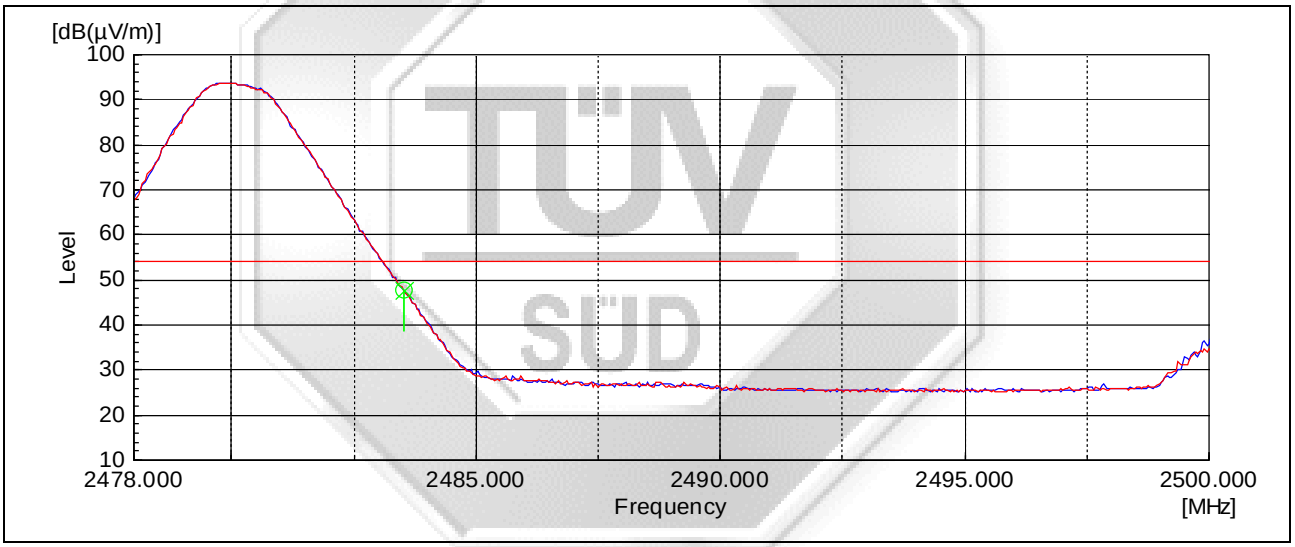
Plot 4 – Average Plot at Lower Band Edge at 2.4000GHz

PSB Singapore

Band Edge Compliance (Radiated) Plots (Restricted Band)



Plot 5 – Peak Plot at Upper Band Edge at 2.4835GHz



Plot 6 – Average Plot at Upper Band Edge at 2.4835GHz